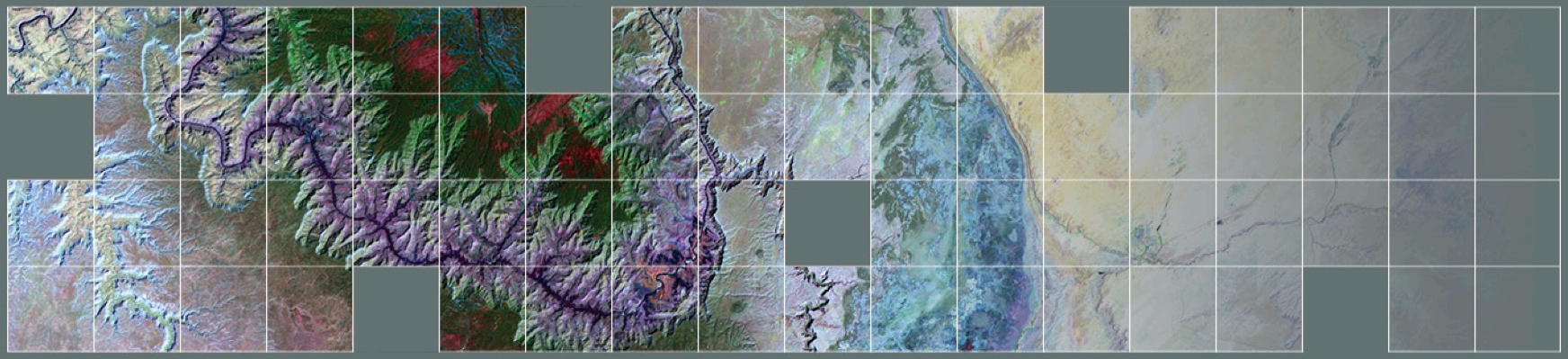
USGS
science for a changing world

USGS, Land Remote Sensing Program

National Land Imaging Requirements



December 4, 2013

U.S. Department of the Interior
U.S. Geological Survey

Evolution of the USGS National Land Imaging Requirements Project

- **President's FY12 budget request that included funding for Landsat 9**
  - Language included "understanding Federal land imaging requirements."
- **Initiated National Land Imaging Requirements Project Plan**
- **Collaboration with NOAA Technology Planning and Integration for Observations (TPIO) office**

USGS EO Requirements Evaluation System Goals

- **Institutionalize the characterization and exploitation of all EO requirements to attain greater awareness of user community needs and potential solutions**
  - Land Remote Sensing (LRS) Focus on service to Land EO Requirements
    - Understanding the broader picture critical
  - Build on Previous Successful Models
  - Design towards a Unified EO requirements architecture
  - Partner with EO community Practitioners
    - Producers and Consumers
    - US Federal
    - International

USGS EO Requirements Evaluation System Goals

- **Program and Budget Justification**
  - Characterization of Communities of use
  - Documentation of requirements being served
  - Valuation of services being delivered

- **Informing Program Direction**
  - Informing Land EO System Design/Development
  - Informing Services Design/Delivery
  - Validating/Adjusting Data/Information Offerings, Informing value added product generation

USGS Requirements Evaluation System Principles

- **Broaden access to user/practitioner community and expand view to all EO requirements and assets/ solutions**

- **Maintain Requirements and Solutions separately**
  - Collect and Maintain requirements in a solution agnostic approach
    - Common Requirements architecture
    - EO Requirements cross over communities of practice and Programs

  - Collect and Characterize solutions in a standardized architecture which will align with the broader EO services community
    - Platform/Sensor Inclusive
      - Space/Air/Land/Sea
    - Products and Services

Joint Approach : Two Complementary Components

System Development

Joint Unified Architecture

- Earth Observation Requirements Evaluation System (EORES)
  - Repository for requirements and capability information
  - Analytical tools

Requirements Elicitation Customizable to Agency Needs

- User Requirements Elicitation
  - All earth observation needs – broad and diverse user community
  - Traceability via value tree
  - Repeatable and transparent process

Joint development with NOAA/TPIO And USGS/LRS Program

Developed from previous and current efforts: NOSIA, NOSIA II, NLIR Mod Rez Pilot.
(Value Tree) + Requirements

USGS

Requirements Elicitation

- **NOT Starting from Scratch!**
  - NOAA (2003-Present)
    - User requirements documentation and validation
      - NOSA, CORL, Casa Nosa…
    - Requirements analysis
    - NOSIA I and II (integrated portfolio analysis)
  - Provided basis for assessment structure in the National Earth Observations Task Force Strategy
  - Landsat Applications Study (NASA/USGS, October 2012)
  - Many years of corporate knowledge
    - Program and solutions specific requirements analysis
  - Joint effort between NOAA and USGS to build off of those bodies of work

USGS

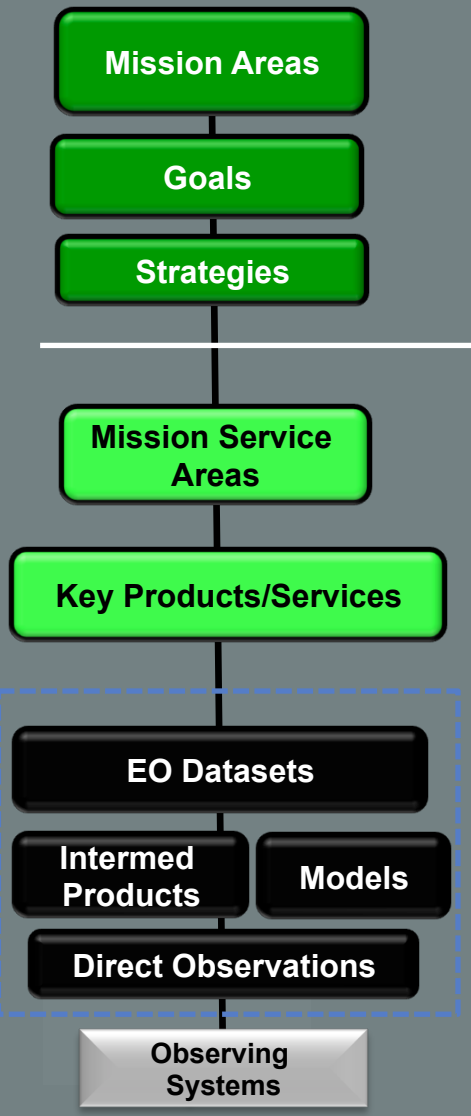
Requirements Elicitation (cont.)

- **Requirements Elicitation Process**
  - Series of step-wise engagements/activities
  - Iterative process, NOT a one-time consultation
  - Customer-focused, customized discussions

- **Some key elements of the methodology**
  - Value Tree
  - Expert Elicitation
  - Multi-Attribute Utility Theory
  - Swing-Weighting

USGS

Organizational Value Tree – Elements



Top of the Tree - from relevant Departmental Strategic Planning documents

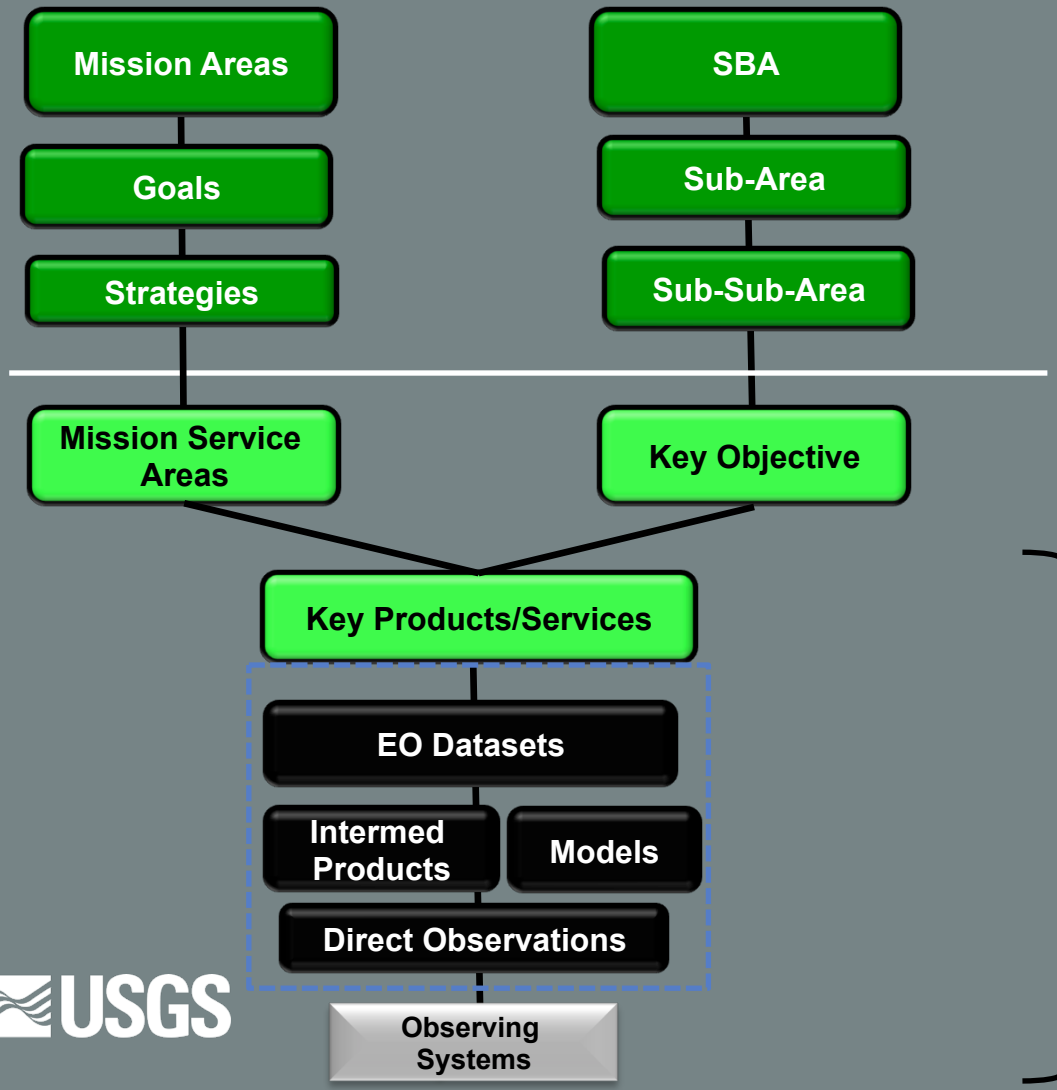
Mission Service Area: A grouping of like activities, products or services intended to achieve a stated agency, office, bureau strategy, goal, or objective

Key Products/Services: The means of delivery of value for the Mission Service Area

Earth Observation Datasets: The information needed to produce Key Products/ Services

- Can consist of intermediate products, model output, or be directly used from observing systems to produce the Key Product

Organizational & Societal Benefit Area Value Trees



Key Products/ Services provide a consistent and enduring component that can be mapped/ remapped to any value tree:

- Organizational
- SBA
- Other

Joint Approach : Two Complementary Components

System Development

Joint Unified Architecture

- **Earth Observation Requirements Evaluation System (EORES)**
  - Repository for requirements and capability information
  - Analytical tools

Joint development with NOAA/TPIO And USGS/LRS

Requirements Elicitation

Customizable to Agency Needs

- User Requirements Elicitation
  - All land imaging needs – broad and diverse user community
  - Traceability via value tree
  - Repeatable and transparent process

Developed from previous and current pilots: NOSIA, EOA, NOSIA II, NLIR Mod Rez Pilot.
(Value Tree) + Requirements

USGS

Earth Observation Requirements Evaluation System (EORES)

- EORES being Developed utilizing AGILE Development Methodology with Interagency development teams
- EORES provides processes, databases and software tools to:
  - Ingest, validate, store, and and prioritize platform-independent user requirements
  - Manage and maintain information describing Earth Observation Systems and solutions
  - Provide data and analyses to inform decisions related to Earth Observation needs, gaps, and priorities, to inform satellite mission formulation and other observing systems decisions
- EORES provides the architecture to store and manage information:
  - Documentation of requirements using a standard set of attributes (temporal, spatial, spectral resolution, coverage, frequency, etc.)
  - NASA Global Change Master Directory (GCMD) base taxonomy
  - Capturing traceability of each requirement to agency missions, service delivery and/or societal benefit using a “value tree” approach

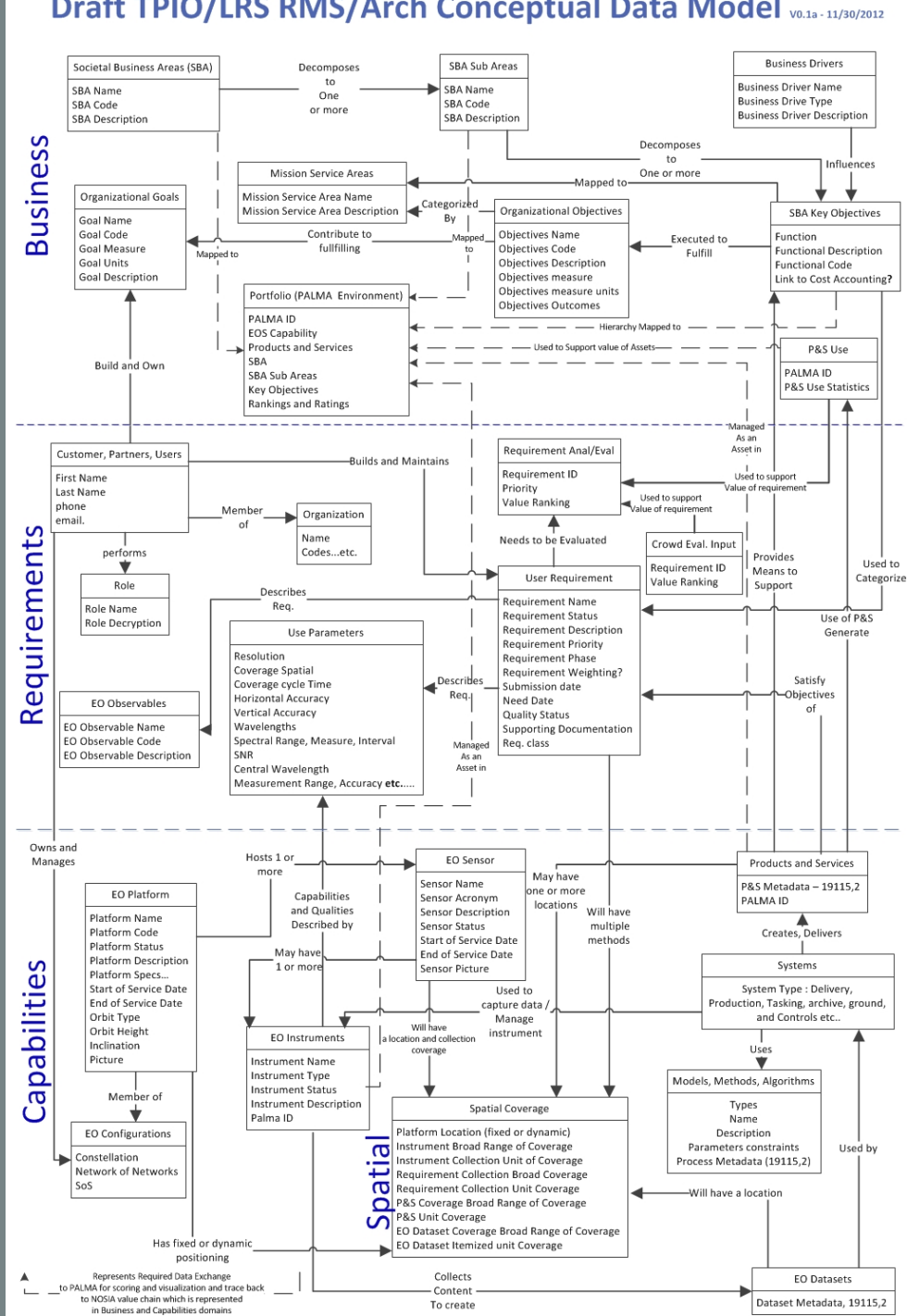
Earth Observation Requirements Evaluation System (EORES)

- **Project Elements**
  - System Conceptual and Logical Design
    - Detailed Analysis and design phase
    - All EO assets and requirements considered
      - Solutions: all platform, all types
      - Requirements: all EO, Land, Air, Ocean…
    - Blueprint for development
  - IT/Software/Database Development
    - Hardware, software and database components
    - Data model to supports current and future analytical needs with standardized nomenclatures, data formats, etc.
  - Working Project as a "Joint Development" with NOAA (TPIO)
    - Leverage resources and experience of both Agencies
    - Goal is a system that will meet both agency's highly-compatible needs
    - AGILE Development Methodology fits joint development
  - Development of Standardized and Enduring Processes***
    - User requirements elicitation, validation, analysis
    - Value tree construction and population (traceability of requirements)

***Processes established must be credible and repeatable

EORES Conceptual Data Model

USGS



Ongoing Activities
Future Steady State

- **Maintain-Expand-Refine-Exercise**
  - EORES Maintenance
    - Systems maintenance/enhancement (DB's, hardware, software, interfaces)
    - Information Maintenance (Content currency: Requirements and solutions)
  - Ongoing Elicitation
    - Addition of Customers, Stakeholders and Communities of interest, adding depth
    - Periodic Re-validation/update of User's Requirements
  - Tools and Processes
    - Tools for analytical support/modeling
    - Processes for program applications/integration

USGS

NLIR Pilot Project (Jun – Dec 2013)

Purpose

- **Develop and test the requirements elicitation methodology, process, and tools**
  - Risk reduction for larger-scale NLI requirements elicitation
  - Evaluate the role/value of existing analytical tools in supporting USGS' needs
  - Determine the sufficiency/adequacy of initial requirements attributes in meeting management needs; refine as needed
- **Provide a representative sample of user requirements that can provide support to near-term needs for mission formulation**

USGS

NLIR Pilot Project

- **Scope**
  - Representative sample of applications/requirements which use moderate resolution imagery
  - Focus on applications using moderate resolution imagery (5-120 m resolution)
  - Both internal and external to DOI to exercise the process
    - Broad topical coverage (see next slide)
    - Focused on identifying SMEs at the right level; generally those engaged in service delivery (direct mission accomplishment) for their organization

USGS

NLIR Pilot Project – Topical Coverage

- Application Areas included in the Pilot Project
  - Agriculture
  - Climate and Land Use
  - Forestry
  - Land Management
  - Mineral Resources
  - Natural Resource Conservation
  - Solid Earth Hazards
  - Surface Mining
  - Water Management
  - Wildlife/Ecosystems

USGS

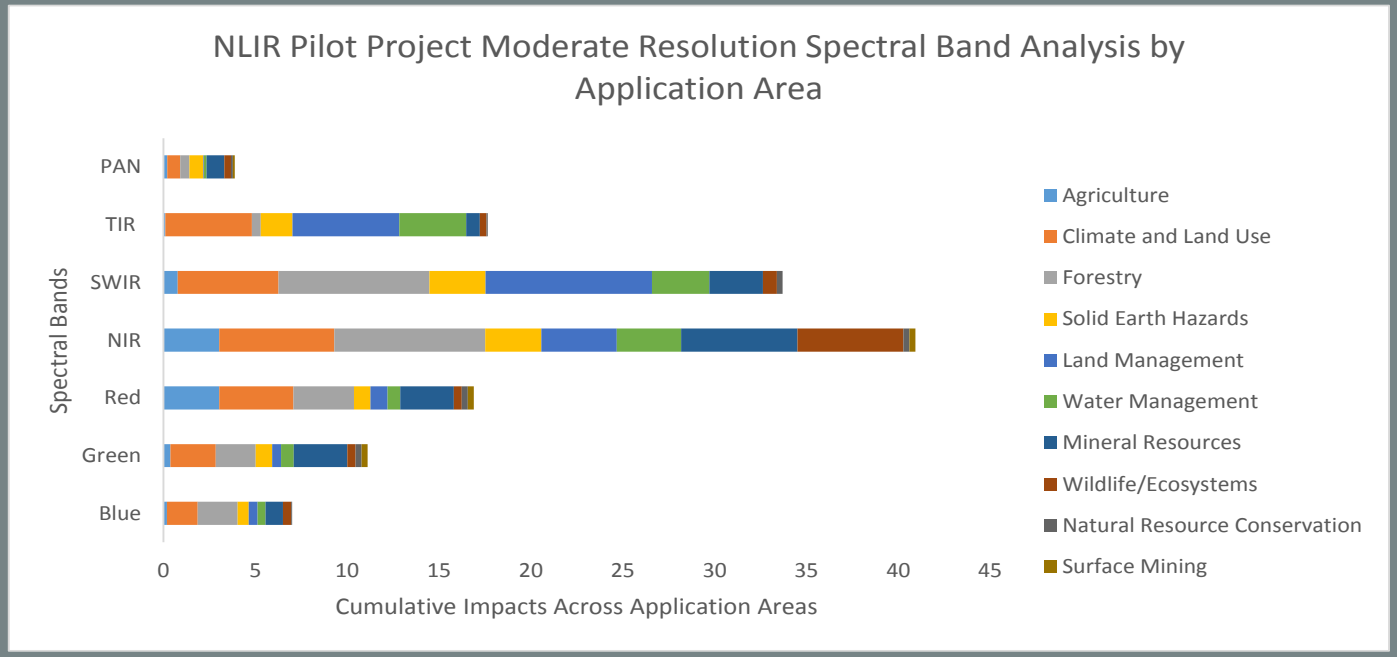
NLIR Pilot Project Process

- **Two major components**
  - **Evaluation of current moderate resolution data sources**
    - **Value tree** construct provides context and traceability for the use of Earth observation data
      - Understand the relative criticality and performance of current moderate resolution data sources on each application
      - Calculate the relative impact of individual Earth observation data sources (down to individual spectral bands) on Application Areas
  - **Elicit user requirements**
    - Document user needs in terms of specific measurements/ information needed, spatial and temporal resolution, geographic coverage, and other attributes

USGS

NLIR Pilot Project

- **From the Value Tree (sample result):**

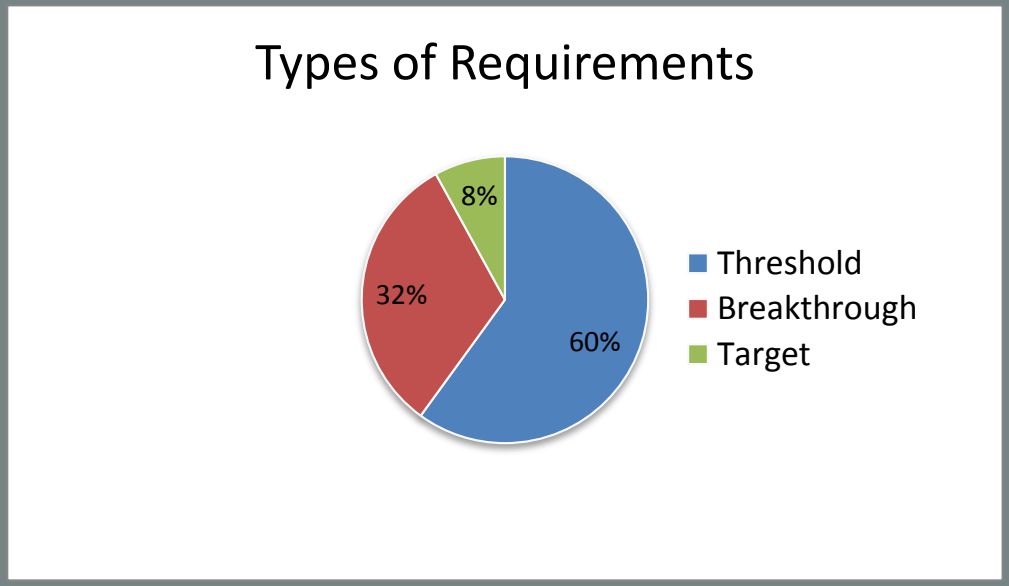


- **Cumulative impact of each of the spectral bands from moderate resolution sources across Application Areas**
  - **Shows which bands overall have the greatest/least impact**

USGS

NLIR Pilot Project

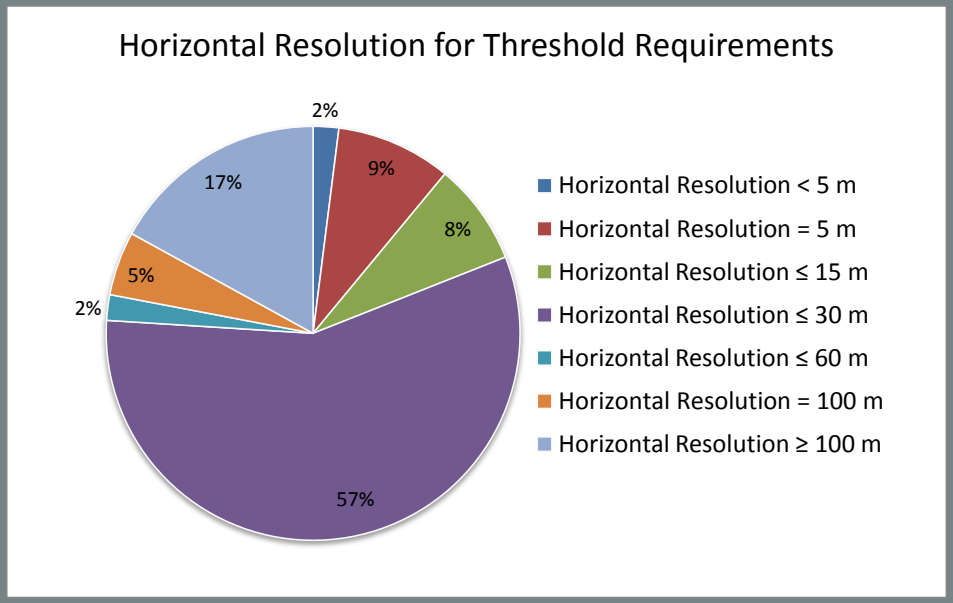
- **User Requirements (preliminary results)**
  - 191 user requirements documented (3 levels)
    - **114 "Threshold" level** – minimum specification to be of any value
    - **62 "Breakthrough" level** – if met would result in significant improvement for the application
    - **15 "Target" level** – specification beyond which only limited additional increase in performance expected for the application

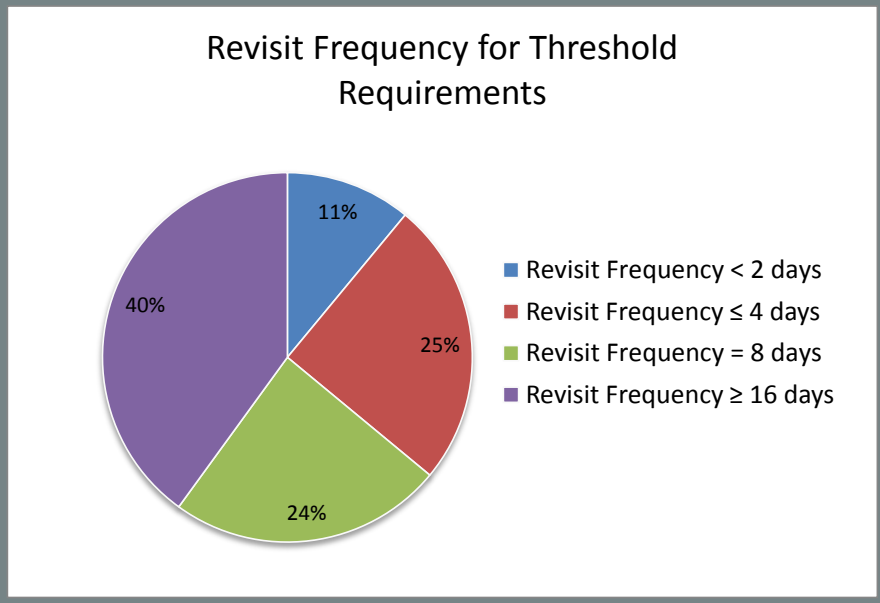


USGS

NLIR Pilot Project

- **User Requirements (preliminary results)**
  - Horizontal Resolution and Revisit Frequency for the 114 Threshold level requirements summarized by category





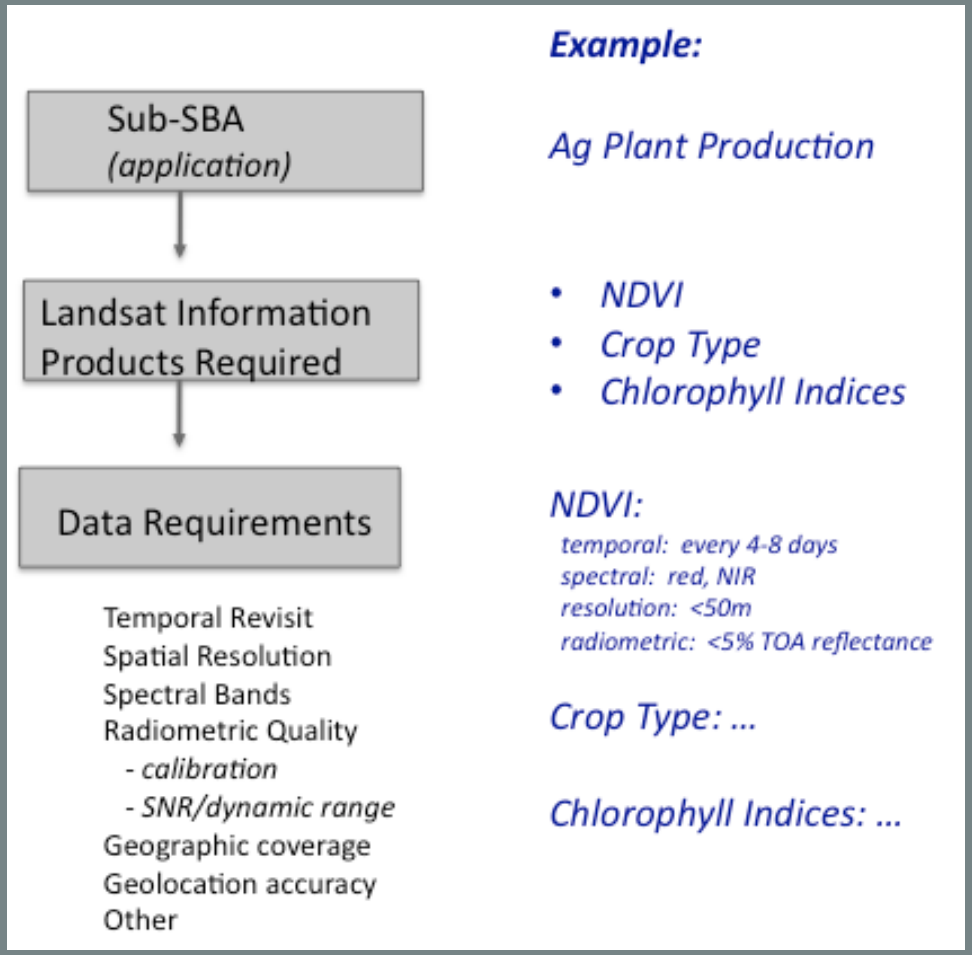
USGS

Requirements to help inform the USGS NASA Architecture Study Team

- **Full capability of the USGS NLI Requirements not available to provide full support**
- **NLI Requirements Pilot project**
- **Previous Art**
  - 40 Years of program engagement
  - Numerous studies and targeted requirements efforts
    - Project, Product, or Sensor specific
  - 2012 Applications Study in support of the USGS/ NASA assessment of alternatives and 2012 Landsat Alternatives RFI

USGS

Applications Study from the 2012 USGS Landsat 9 RFI



Applications Study 2012 RFI

Spectral and Radiometric Requirements for Surveyed Applications

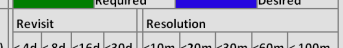
Table 2. Spectral and Radiometric Requirements for Surveyed Applications		Required						Desired		
		Spectral Requirements							Radiometric Requirements	
Application	Information Product	VIS	NIR	SWIR	TIR	Red Edge	Other		Calibration	Bit depth/SNR
National Land Cover Database (NLCD)	Cover Type/Change	■	■	■					< 5% rad	
	% Treecover	■	■	■					< 5% rad	
	% Impervious	■	■	■	■				< 5% rad	
USGS/USFS Landfire	Vegetation characteristics	■	■	■	■				< 5% rad	8-bits
	Disturbance	■	■	■	■				< 5% rad	8-bits
Burned Area Emergency Response (BAER)	Burn severity maps (dNDVI, dNBR)	■	■	■						
FAO FRA Forest Change	Forest change maps	■	■	■					< 5% rad	
Foreign Agricultural Service (FAS)	Crop area	■	■	■						
	Crop production	■	■	■		■				
	Crop health	■	■	■		■				
National Agricultural Statistical Service (NASS)	National cropland data layer (crop type)	■	■	■						
USDA Crop Insurance/Disaster	Verification of Crop Insurance/Disaster Claims	■	■	■						
Western States Evapotranspiration	Land surface temperature				■				<2% rad	NEdT<1.5K
	Surface reflectance	■	■	■					<5% SR	
	NDVI	■	■						<5% SR	
	Cloud/shadow mask	■	■		■					
USDA Tillage/Residue Monitoring	Crop residue		■	■			■			>250 SNR
Landsat Image Mosaic of Antarctica (LIMA)	Ice sheet features		■						< 5% rad	12-bits
Minnesota Lake Clarity Monitoring	Water clarity	■					■		0.5% (?) TOA	12-bits
USFS Forest Management	Terrestrial Ecologic Unit Inventory	■	■	■					<5% TOA	12 bits
	Mid-level Vegetation classification	■	■	■					<5% TOA	12 bits
	National insect disease risk map (NIDRM)	■	■	■					<5% TOA	12 bits
	Post-storm damage assessment	■	■	■					<5% TOA	12 bits
	Rapid Assessment of Vegetation Post-fire (RAVG)	■	■	■					<5% TOA	12 bits
MDA/NGA Land Change	Correlated land change (new construction)	■	■	■	■				stable TOA	> 11 bits
Ohio Agricultural Tax Verification	NDVI (to establish presence of crops)	■	■							
USGS Volcano monitoring	At-sensor radiance (plumes, minerals)	■	■	■	■		■		<4% rad	
	Surface temperature				■		■		<4% rad	
USGS Flood Monitoring	At-sensor radiance (flooded area)	■	■	■	■				<4% rad	> 10 bits
USGS Essential Climate Variables (ECVs)	Surface reflectance	■	■	■					<5% rad	> 10 bits
	Surface temperature				■				<2% rad	> 10 bits
	Land cover & surface water extent	■	■	■	■				<5% rad	> 10 bits
	LAI/fPAR	■	■	■					<5% rad	> 10 bits

USGS

Applications Study 2012 RFI

Revisit and Spatial Requirements for Surveyed Applications

Table 3. Temporal Revisit and Spatial Resolution Requirements for Surveyed Applications



Application	Information Product	Revisit (days)	Resolution (m)	Geolocation (m)	Revisit				Resolution				
					< 4d	< 8d	<16d	<30d	<10m	<20m	<30m	<60m	< 100m
National Land Cover Database (NLCD)	Cover Type/Change	16	30	<15 m									
	% Treecover	16	30	<15 m									
	% Impervious	16	30	<15 m									
USGS/USFS Landfire	Vegetation characteristics	8	30	< 0.5 pix									
	Disturbance	8	30	< 0.5 pix									
Burned Area Emergency Response (BAER)	Burn severity maps (dNDVI, dNBR)	8 (4)	10 to 60	0.5 to 1.0 pix									
FAO FRA Forest Change	Forest change maps	16	30	< 0.5 pix									
Foreign Agricultural Service (FAS)	Crop area	7	30	coreg/ortho									
	Crop production	7	30	coreg/ortho									
	Crop health	7	30	coreg/ortho									
National Agricultural Statistical Service (NASS)	National cropland data layer (crop type)	5	30	coreg/ortho									
USDA Crop Insurance/Disaster	Verification of Crop Insurance/Disaster Claims	7	30	coreg/ortho									
Western States Evapotranspiration	Land surface temperature	16 (4)	30 to 120	< 15m									
	Surface reflectance	8	30	< 15m									
	NDVI	8	30	< 15m									
	Cloud/shadow mask	8	30	<15m									
USDA Tillage/Residue Monitoring	Crop residue	8	30 to 60										
Landsat Image Mosaic of Antarctica (LIMA)	Ice sheet features	30 (7)	15	<50m (15m)									
Minnesota Lake Clarity Monitoring	Water clarity	8 (4)	50(30)	< 10m									
USFS Forest Management	Terrestrial Ecologic Unit Inventory	8	5 to 30										
	Mid-level Vegetation classification	8	10 to 30										
	National insect disease risk map (NIDRM)	8 (4)	30										
	Post-storm damage assessment	4	30										
	Rapid Assessment of Vegetation Post-fire (RAVG)	4	30										
MDA/NGA Land Change	Correlated land change (new construction)	30 (8)	30 (15)										
Ohio Agricultural Tax Verification	NDVI (to establish presence of crops)	16	30										
USGS Volcano monitoring	At-sensor radiance (plumes, minerals)	16 (8)	30 (15)										
	Surface temperature	16 (8)	60 to 90										
USGS Flood Monitoring	At-sensor radiance (flooded area)	8	30 (15)										
USGS Essential Climate Variables (ECVs)	Surface reflectance	8	30										
	Surface temperature	8	120										
	Land cover & surface water extent	16	30										
	LAI/fPAR	8	30										

USGS

Thank You

- Panel Session will use a similar applications based approach to discuss Observational Requirements and System Parameters

- Contact

John L. Crowe
Land Remote Sensing Program
US Geological Survey
517 National Center
12201 Sunrise Valley Drive
Reston, VA 20192
Ph. : (703) 648-5596
E-mail : jcrowe@usgs.gov

USGS